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[1]**Vladimir P. Kvasnikov**, Prof.
[2]**Vitaliy Yu. Larin**, Assoc. Prof.
[3]**Nina I. Chichikalo**, Prof.
[4]**Yaroslava G. Rodchenko**, student

# THE MOISTURE METER OF THE DOUGH SEMI-FINISHED PRODUCTS

[1,2]National Aviation University
E-mail: vjlarin@gmail.com.ua
[3,4]Donetsk National Technical University
E-mail: Chichikalo@rambler.ru

**Abstract.** *In the article a new method and device of measuring of humidity of semi-finished products is offered from a test which is based on measuring of free falling time of purveyance from a dough in an air environment under the action of gravity. The basic factors of external environment, influencing on humidity of purveyances of tests - pressure and temperature, are marked. By a mathematical design the analysis of influencing of atmospheric pressure and temperature is conducted on humidity of purveyances from the dough.*

**Keywords**: humidity meters, oscillation transformer, products from a dough, simulation.

## Introduction

Nowadays quality-strengthening control is requested in all industrial and food industries. The subject is devoted to the area of measuring devices for bakery production.

The parameters of bread quality come from a research object: moisture of dough semi-finished products being certainly influenced by atmospheric pressure, a temperature and moisture in the technological process apartment.

The non-observance of norms with mentioned parameters conduces to the receipt of poor quality products and as a result - is the moral and material losses.

## Basic material

One of major parameters influences on a crumb formation and determined on the primary stage, is moisture of dough semi-finished products. The level of moisture must correspond to the State Standard norms [1], then crumb will not lose necessary biomatters, fluffiness, flavour, will be done and will provide the designated product yield.

A technological process of bread production consists of the responsible stages [2], from the necessary ingredients weighing, pre-mixing.

During pre-mixing the intensity and duration are very important. Next, the process goes into fermentation brew.

After the re-kneading with the addition of some components future bread put to mechanical treatment, like division into pieces, mould into round shape, proof, place into tin, the final proof and baking.

The moisture (mass) $W$ [3] is considered as correlation of moisture masses $M$, contained in a body, with moist material mass $M_1$:

$$W = \frac{M}{M_1} = \frac{M}{M_0 + M}.$$

Moisture is measured by the special devices [4; 5], which are divided as psychrometers, hygrometers, balance moisture meters, conductometric moisture meters, dielcometer moisture meters, moisture meters of nuclear magnetic resonance and other depending on a method, fixed in basis of their work.

The industrial methods are most wide-spread [6].

These methods are based on a physical or chemical division of moisture and dry material, determination of their balance or by volumetric analysis.

However a basic defect is an impossibility of using these methods as an informative link in automatic control and continuous technological processes control, and also in research of moisture exchange processes and moisture to material form connection change.

There are many methods of moisture determination were found [6] - the drying method, the oven drying method, extraction method, chemical method, conductometric and dielcometric methods, the nuclear magnetic resonance method, etc.

Among considered methods the most widespread is the drying method. However, it has significant disadvantages.

The hygrometer of Chizhova is based on this method [7], (fig. 1), causes obvious disadvantages.

Fig. 1. Chizhova Hygrometer for humidity measuring

The device supposes:

– the necessity of analyzable semi-finished product extraction from a continuous technological process;

– the absence of the objective fixing moment of the moisture complete moving away in the drying process;

– the necessity of the repeated measuring realization (during a technological process);

– the insufficient probability of result.

Therefore, after estimating disadvantages, we offer the device. Its mathematical apparatus is based on the law of solid falling under gravity. The basis of the developed system is expected to put the principle of dough pieces weight influence and applied to it the buoyancy force, which is neglected in the process of further calculations by its smallness, depending on the passed (fixed) distance [8].

$$P - T = m\frac{d^2y}{dt^2},$$

where $m$ – mass of semi-finished products;

$y$ – controlled by the distance traveled by semis test.

Differentiating the equation of dough semi-finished products motion from the moment of dividing in dough dividing machine until contact with the shipping container, were taken into account all the factors affecting the dough semi-finished product: temperature, pressure, density of air.

$$\frac{d^2t}{dt^2} = g\left[1 - \left(\frac{\rho_b}{\rho_n}\right)\right],$$

where $g$ – free fall acceleration;

$\rho_b$ – density of the interacting medium (air) ;

$\rho_n$ – semi-finished product density.

Time drop $t$ from point B to point C (the location of non-contact sensors) is:

$$t = \sqrt{\frac{2b}{g}\cdot\frac{\rho}{\rho-\rho_c}} - \sqrt{\frac{2a}{g}\cdot\frac{\rho}{\rho-\rho_c}}\ .$$

Thus, the method of universal moisture meter based on measuring the dough pieces fall in the air by the force of gravity between two fixed points in space, where have established static non-contact sensors. The final calculation of the moisture got by the formula:

$$W = \frac{3.614\cdot10^{-3}\cdot\frac{P}{T} - \rho\cdot\left(1-\frac{2S}{g\cdot t^2}\right)}{985.4 - 5.75\cdot(t-2)^2 - 35.45\cdot\frac{t-100}{50} - \rho_{sv}}.$$

**Scientific novelty**

Among all known moisture measuring devices, there is no such a device for controlling moisture in real time.

The device for moisture determination - by Chijeva is considered as a prototype, however another control method will be offered.

New method is based on the laws of physics and mathematics.

Therefore there are substantial differences:

1. Method of moisture determination and control.
2. The device by Chijeva does not function in real time for rapid moisture determination.
3. The device control is selective for all dough streams and it is carried out several times (the bread output control, estimations of intermediate product and at the recipe verification).
4. The offered sensor is simple in the use and has high accuracy.

So, we proposed new method of constructing a moisture meter that can also determine the moisture in the bake house. Based on the developed mathematical model and based on the device design, it is clear that moisture is determined by measuring the wet sorbent fall in the hygrometer chamber of discrete steps.

Generator sensors. The sensors of this type [9] are used for time-falling fixing of dough semi-finished product.

The gages differ with a compactness and high accuracy. To fix the time of the dough semi-finished products fall are used static contactless sensors with discrete output signal [9].

Generator sensors of HPC and HPC-6M-25 (slot), the OHR and OHR-8-16 (flat-sensitive element) series are very effective.

They are suitable for use in high concentration of moisture and dust.

Sensors CWT-8 and OHR-16 trigger when the metal plate passes through them. The maximum controllable range is 8 and 16 mm.

With the help of MathCAD the impact of external and structural factors in the dough semi-finished product moisture was evaluated, and were found the optimal conditions for reliable determination of moisture: the temperature of 25-30ºC and the distance between the static non-contact sensors from 10 to 50 cm.

**The influence of atmospheric pressure on moisture dough semi-finished products**

The moisture of bodies is determined by water presence as a steam [10]. The steam amount depends on partial pressure of aquatic steams, for example in the air at this temperature and atmospheric pressure that testifies about the atmospheric pressure influence on dough products moisture. Let's follow such a plot by means of formula:

By *P1*=79993.2 Pa, *P2*= 86659.3 Pa,
*P3*= 93325.4 Pa, *P4*= 99991.5 Pa,
*P1*= 106657.6 Pa,
t = 20 ms, g = 9.80665 m/s$^2$ , $\rho_{sv}$ =1420 kg/m$^3$ ,
$\rho$ =1.6 kg/m$^3$, T=24ºC, S=0.1 m.
Next dependence (fig. 2) is got:

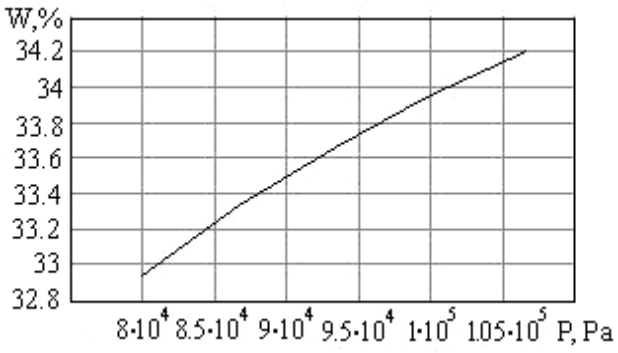


Fig. 2. The atmospheric pressure influence on dough semi-finished products moisture

**Effect of ambient temperature on dough products moisture**

Using the same mathematical tools, but changing the temperature in the room we can get a characteristic dependence of moisture and temperature.

By *P*700= 93325.4 Pa,
t = 20 ms, g = 9.80665 m/s$^2$,
$\rho_{sv}$ =1420 kg/m$^3$ ,
$\rho$ =1.6 kg/m$^3$,
S=0.1 m,
however T1=10 ºC,
T2=15 ºC,
T3=20 ºC,
T4=25 ºC,
T5=30 ºC,
T6 = 35 ºC,
T7=40 ºC,
T8 = 45 ºC.
Next dependence is got (fig. 3).

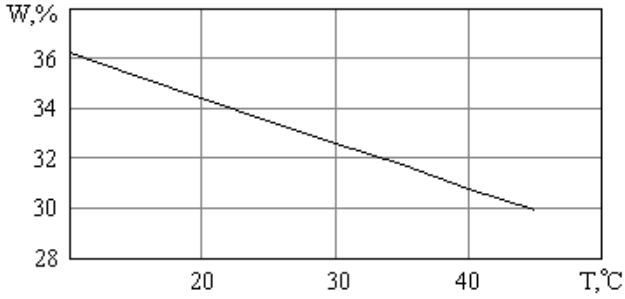


Fig. 3. The temperature influence on dough semi-finished products moisture

The graph shows that the temperature in the technological space is inversely affects on moisture.

So, while temperature increase there is occur a reduction of the dough moisture percentage.

When the temperature varies from 10ºC to 45ºC moisture decreases by 16,6%.

Obviously the room temperature varies in small limit so the effect of temperature can be considered insignificant.

**Conclusions**

1. A new method of determination of moisture of dough semi-finished product is proposed.

2. A mathematical model for determination semi-finished products moisture is developed.

3. The influencing factors on the reading are established.

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